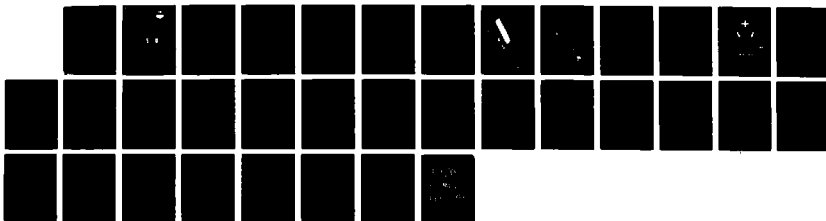


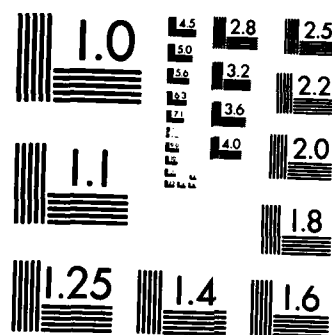
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POLYCHLORINATED BIPHENYL (PCB) SAMPLING CAVALIER AFS  
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ENVIRONMENTAL HEALTH LAB BROOKS AFB TX I ATKINS AUG 87  
UNCLASSIFIED USAFOEHL-87-109EH0251HGA F/G 24/7

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MICROCOPY RESOLUTION TEST CHART  
NATIONAL BUREAU OF STANDARDS-1963-A

USAFOEHL REPORT

87-109EH0251HGA



**POLYCHLORINATED BIPHENYL (PCB) SAMPLING,  
CAVALIER AFS ND**

ISAAC ATKINS, JR, CAPTAIN, USAF, BSC

August 1987

Final Report

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**USAF Occupational and Environmental Health Laboratory  
Human Systems Division (AFSC)  
Brooks Air Force Base, Texas 78235-5501**

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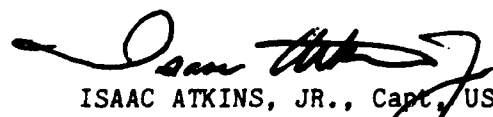
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This report has been reviewed and is approved for publication.

  
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<p>HQ AF SPACECOM/SGB requested USAFOEHL to determine if maintenance personnel, who conduct periodic maintenance inside transmitter cabinets located in room 301, Phased Array Radar Building, Cavalier AFS ND were exposed to hazardous levels of polychlorinated biphenyls (PCBs) and its combustion products. This report explains how USAFOEHL determined ambient and surface levels of polychlorinated dibenzodioxins (PCDDs), polychlorinated dibenzofurans (PCDFs) and PCBs. Additionally, two PCB oil samples were analyzed to determine the level of PCDD and PCDF formation. The PCDDs and PCDFs of interest included 2,3,7,8-tetrachlorodibenzodioxin (TCDD) and 2,3,7,8-tetrachlorodibenzofuran (TCDF) as well as the tetra through octa chlorinated congener classes of dioxins and furans.</p>					
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## I. INTRODUCTION

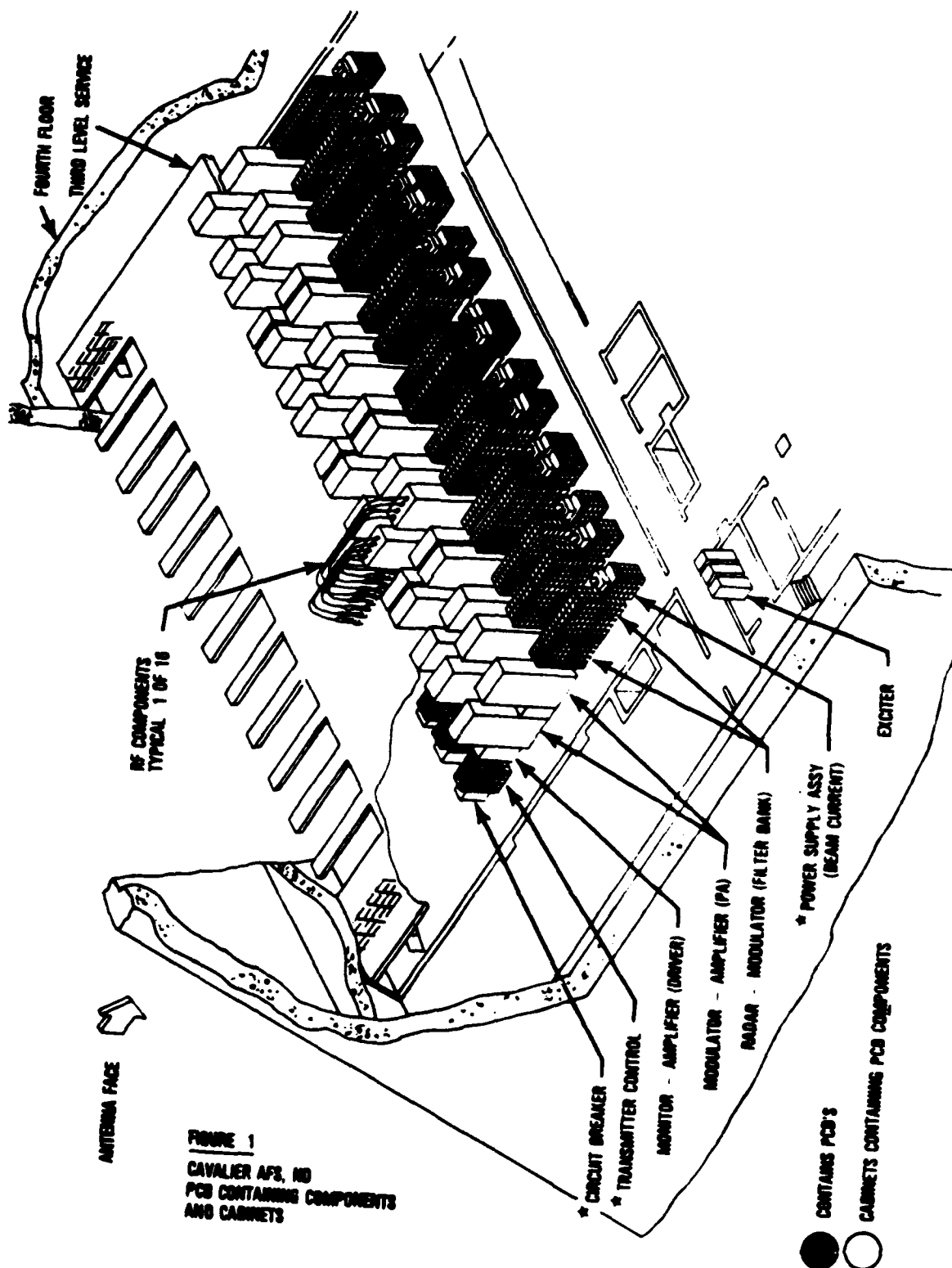
### A. Background

On 13-16 Apr 86 a team of certified industrial hygienists from A.F. Meyer and Associates, Inc. conducted an on-site investigation of polychlorinated biphenyl (PCB) contamination in room 301, Phased Array Radar (PAR) Building, Cavalier AFS ND. The purpose of the survey was to assess the level of PCB contamination inside transmitter cabinets 9 and 10, determine alternative means of mitigation, and estimate the facility's decontamination cost. The report concluded the principal hazards were electrical shock from high electrical voltages, exposure to PCB residues, and possible exposure to polychlorinated dibenzodioxins (PCDDs), and polychlorinated dibenzofurans (PCDFs). Because of these findings a Risk Assessment Code (RAC) of 2 was assigned to the facility. A RAC 2 means serious harm can and probably will result from the existing conditions.[1]

As shown in Figure 1, PAR building, room 301 is a nonoccupied room which contains 16 transmitter cabinets. Each transmitter group is comprised of 17 PCB capacitors containing 7.6 gallons of Aroclor 1242 dielectric fluid and one A-20 resistor assembly containing 3 to 4 gallons of the same mixture (Figure 2). Capacitors are sealed electrical components that store energy in the form of an electrical field using a system of conductors. The A-20 resistor assemblies are sealed metal tubs containing electrical components in a PCB cooling bath. Each resistor has a pressure relief valve located near the top. The purpose of this valve is to vent off internal pressure. A review of the maintenance records indicated a system design flaw caused the capacitors to rupture and the A-20 resistors to overheat resulting in leakage and venting of vaporized PCB inside the transmitter cabinets. Cooling fans located at both ends of the cabinets distributed the PCB throughout the interior of the transmitter group.

Because this installation plays a vital role in our national defense, the A.F. Meyer team recommended comprehensive testing of the interior of the transmitter cabinets. On 22 Oct 86 HQ AFSPACECOM/SCB requested USAFOEHL determine if maintenance personnel, who conduct periodic maintenance inside the transmitter cabinets, were exposed to hazardous levels of PCBs, PCDDs, or PCDFs.

During the period of 27-31 Oct 86, USAFOEHL collected bulk, air and swipe samples for PCBs, PCDFs, and PCDDs in four transmitter cabinets suspected of heavy PCB contamination. PCB air samples were also collected in room 301. Results indicated the PCB concentrations in the room were below one-half the 8-hour time-weighted average (TWA) concentration of 1 milligram per cubic meter (mg/m<sup>3</sup>) for 42% chlorine PCB recommended by the Occupational Safety and Health Administration (OSHA). Also, trace amounts of PCDFs and PCDDs were detected in bulk, air, and swipe samples.



**FIGURE 1**  
CAVALIER AFB, MD  
PCB CONTAINING COMPONENTS  
AND CABINETS

# RADAR TRANSMITTER GROUPS (16 REQUIRED)

Cabinet      Nomenclature      P/N      QTY

DC-DC Current  
Power Supply

11253790      1

Radar  
Modulator

Capacitor C1-C8 14F1517G2  
Capacitor C9-C16 14F1516G2  
Helix Power Supply PS2 ZTS7  
Regulator Assembly A20

11263455      8  
11263456      8  
1125160      1  
11259469      1

Amplifier  
Modulator

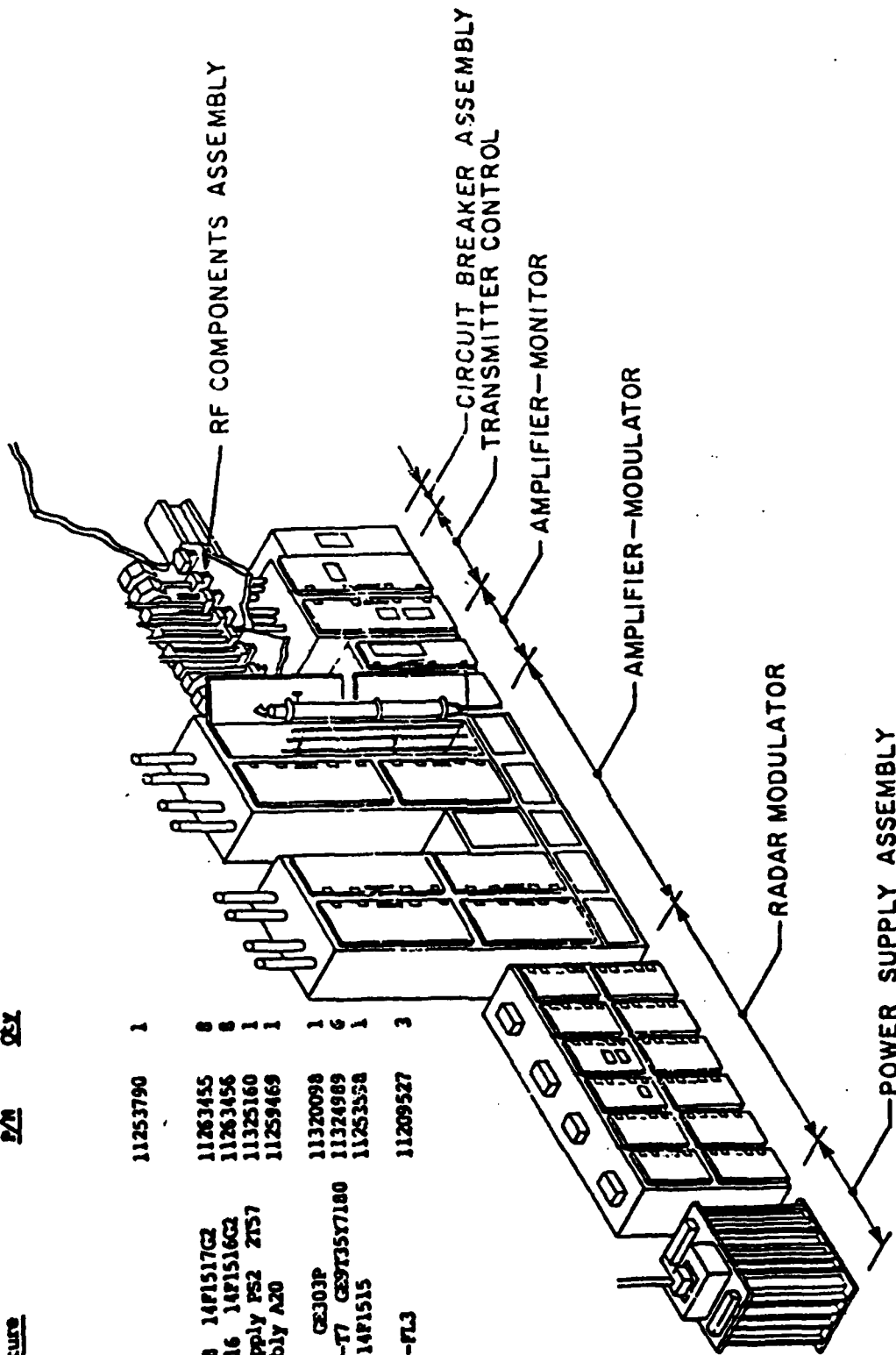
Transformer T1 GE303P  
Transformer T2-T7 GE3T357180  
Capacitor C1 14F1515

11320098      1  
11324989      6  
11253558      1

Transmitter  
Control

RFI Filter FL1-FL3

11209527      3



0 1 2 3 4 5 6  
SCALE: FEET  
(APPROX)

\* 23 Non PCB Capacitors in system.

FIGURE -2. RADAR TRANSMITTER GROUP Pn: 301

## B. Objective of Current Report

The purpose of this report is to explain how USAFOEHL determined ambient and surface levels of PCDDs, PCDFs, and PCBs at Cavalier AFS. Two PCB oil samples were also analyzed to determine the level of PCDD and PCDF formation. The PCDDs and PCDFs of interest included 2,3,7,8-TCDD and 2,3,7,8-tetrachlorodibenzofuran (2,3,7,8-TCDF) as well as the tetra through octa chlorinated congener classes of dioxins and furans.

## C. Survey Personnel

Major Randall C. Ostraat, Consultant, Industrial Hygiene Engineer  
Capt Isaac Atkins Jr, Consultant, Industrial Hygiene Engineer  
1Lt Kul B. Garg, Consultant, Industrial Hygiene Engineer  
2Lt Anthony Zimmer, Consultant, Industrial Hygiene Engineer

# II. SAMPLING AND ANALYSIS

## A. Sampling

### PCB

Two PCB oil samples were collected, one from a ruptured capacitor and the other from an overheated A-20 resistor assembly. The samples were collected in a 12 ounce amber jar with a Teflon<sup>R</sup> lined cap. Each jar was filled to the top to exclude air from contaminating the sample. The samples were wrapped in aluminum foil and sent to the lab for analysis.

NIOSH Method 5503 was used to determine ambient PCB concentrations inside the cabinets. Method 5503 consists of a 13 mm glass fiber filter (without binders) housed in a Swinnex cassette. This device was followed by a 7 cm long, 6 mm OD, 4 mm ID glass tube containing two sections of 30/48 mesh deactivated florisisl. The sampling was conducted for a minimum of 6 hours using low flow Alpha-1 pumps at a flowrate of 0.15 liters per minute (LPM). The limit of detection (LOD) was 5 micrograms ( $\mu$ g).[2]

NIOSH Method 5503 was modified to determine low level PCB concentrations in the room. Instead of a florisisl tube, a two-stage high volume air sampler was used (Figure 3). The first stage consisted of a 47 mm glass microfiber (0.3 micrometers) particulate filter and the second stage contained a glass absorption cartridge containing glass wool and 8 grams of 60/100 mesh deactivated florisisl. The glass cartridge containing the florisisl was housed in an aluminum housing and sealed with fluorlastomer viton "O" rings. Prior to sampling, the florisisl was placed in an oven and dried at 103°C for 24 hours to remove moisture. The sampling was conducted using high flow Millipore pumps at a flowrate of 12, 13, 13.5, 13.7 and 14 LPM for a minimum of 24 hours. The LOD was 10 picograms.

PCB swipe samples were collected by wiping surfaces with chemically precleaned 3 by 3 inch cotton gauze pads wetted with hexane. A 100 square centimeter ( $\text{cm}^2$ ) area was marked with a template and wiped in a nondirectional pattern in at least two directions at 90 degrees to one another (Figure 4), then placed in an amber jar with a Teflon lined cap.[3] The objective of this procedure was to collect swipe samples that were quantitative and reproducible.

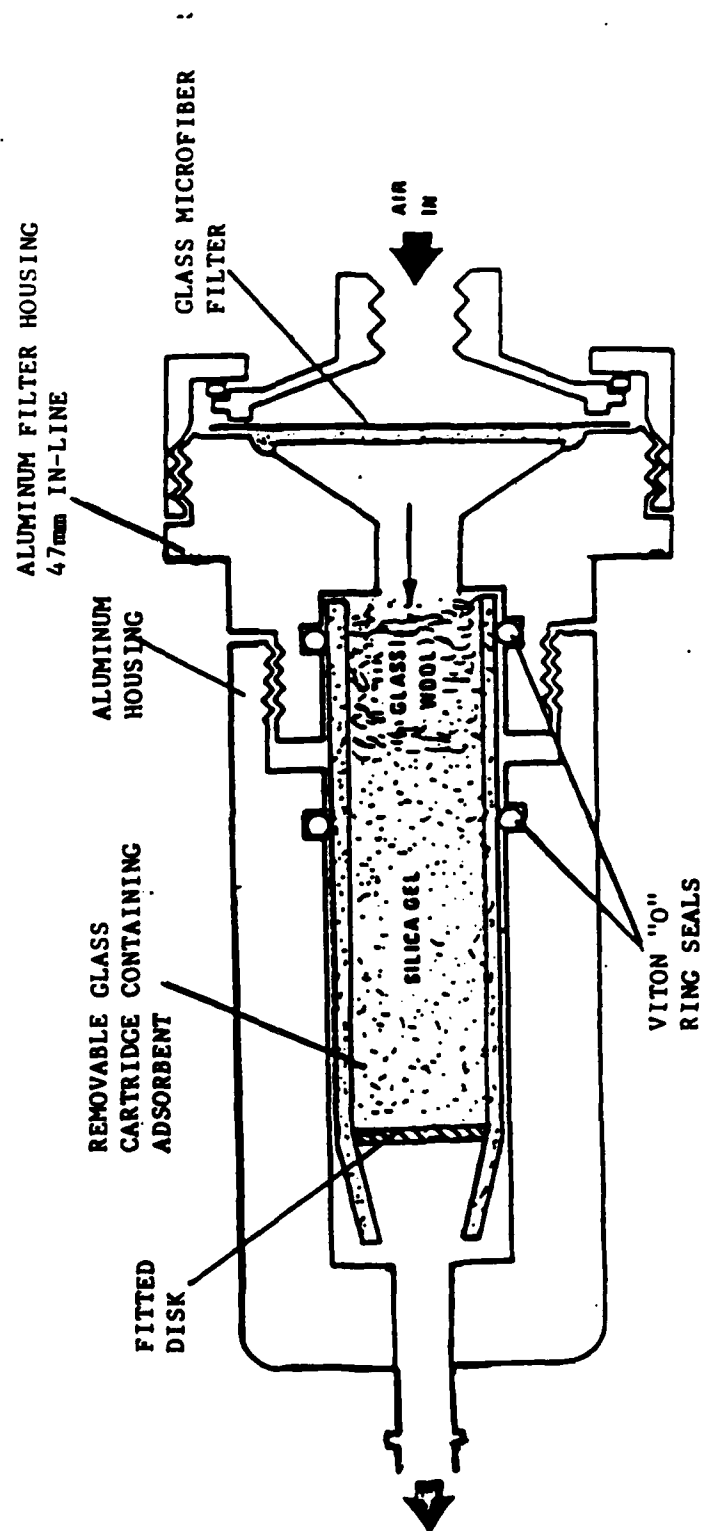
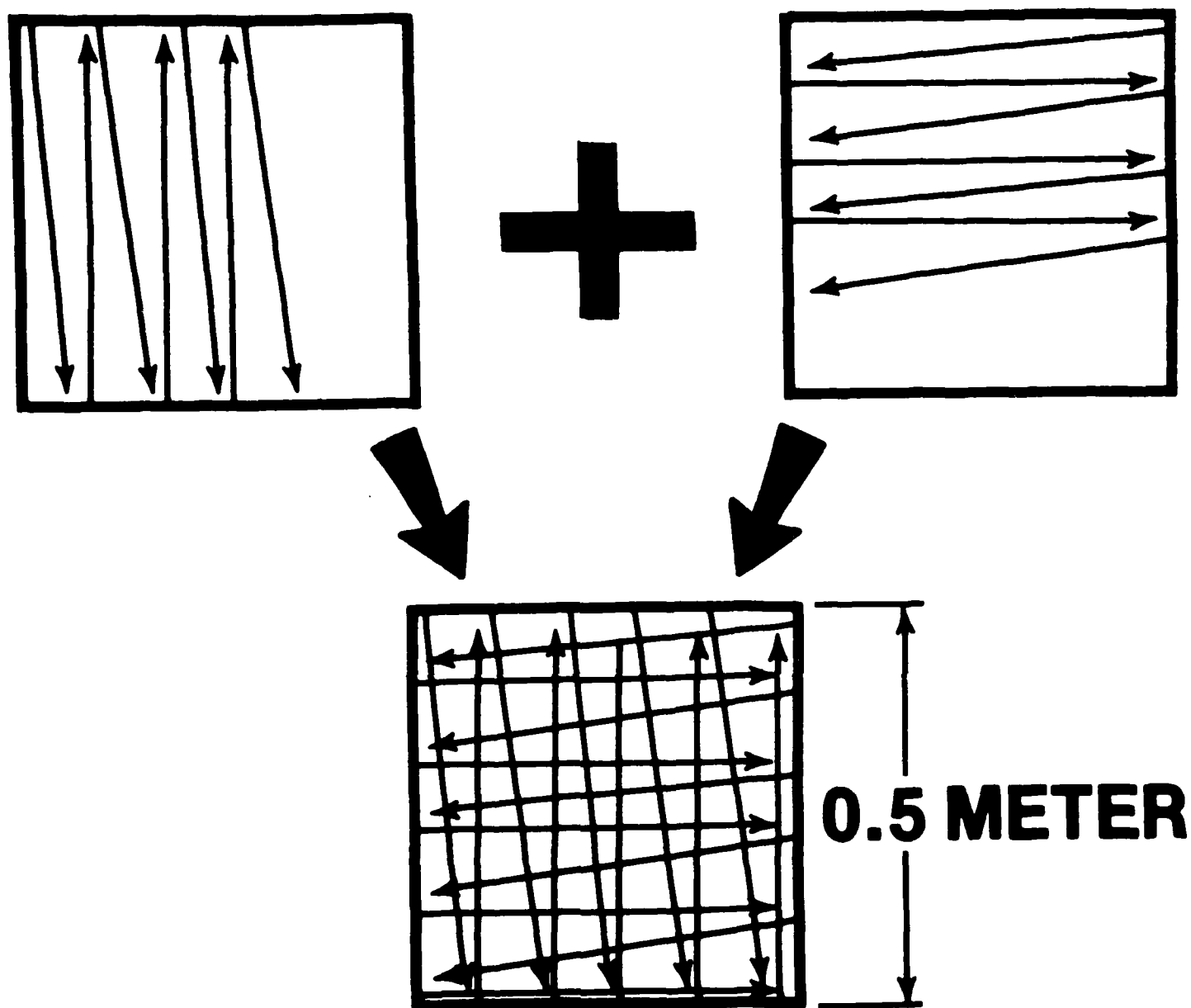


FIGURE 3. TWO STAGE AIR SAMPLING DEVICE FOR PCDFs/PCDDs  
DEVELOPED BY USAFOEHL



**FIGURE — 4. WIPE PATTERN**

## PCDD/PCDF

Air samples for PCDFs and PCDDs were collected using the same two-stage device as described above; however, a different absorption media was used. The glass cartridge contained 8 grams of 140°C activated 30/40 mesh silica gel instead of florisil. The silica gel cartridges were spiked with isotopically labelled internal standards prior to sampling. The sampling was conducted using high flow Millipore pumps at a flow rate of 25 and 26 LPM for a minimum of 24 hours. The LOD was 1 picogram per sample per congener class.

PCDD and PCDF swipe samples were collected using chemically precleaned 3 by 3 inch cotton gauze pads wetted with hexane. The method was the same as the PCB swipe sampling method except each 100 cm<sup>2</sup> area was wiped four times with a different gauze pad. The four pads represented one sample.

### B. Analysis

#### PCB

The two PCB oil samples were analyzed to determine if the overheat condition produced PCDDs or PCDFs. The analysis was performed by Radian Laboratory using EPA Method 8280. The samples were analyzed using a Hewlett-Packard 5985 gas chromatograph which interfaced directly into a mass spectrometer.

Before extraction an internal standard solution containing the following radio labeled C-13 PCDDs/PCDFs were added to the raw samples:

<sup>13</sup> C <sub>12</sub> -2,3,7,8-TCDD	<sup>13</sup> C <sub>12</sub> -2,3,7,8-TCDF
<sup>13</sup> C <sub>14</sub> -2,3,7,8-TCDD	<sup>13</sup> C <sub>12</sub> -1,2,3,7,8-Penta CDF
<sup>13</sup> C <sub>12</sub> -1,2,3,7,8-PentaCDD	<sup>13</sup> C <sub>12</sub> -2,3,7,8-HexaCDF
<sup>13</sup> C <sub>12</sub> -1,2,3,6,7,8-HexCDD	<sup>13</sup> C <sub>12</sub> -2,3,7,8-HeptaCDF
<sup>13</sup> C <sub>12</sub> -1,2,3,4,6,7,8-HepDD	<sup>13</sup> C <sub>12</sub> -OctaCDF
<sup>13</sup> C <sub>12</sub> -OctaDD	

The native PCDD/PCDF quantitation was performed using specific ion response ratios of the native PCDDs/PCDFs to the C-13 internal standard analogs for each isomer class. In cases where the C-13 standard was not recovered or interference precluded its measurement, quantitation was generated from a 0.5 microgram per milliliter (µg/ml) solution containing the native analogs for each of the C-13 PCDD/PCDFs in the internal standard solution. Surrogate recoveries were measured relative to <sup>13</sup>C<sub>12</sub> -1,2,3,4-TCDD which was added to each extract before GC/MS analysis. In both samples, <sup>13</sup>C<sub>12</sub> -2,3,7,8-TCDD was not recovered, therefore, TCDD detection limits could not be calculated. Also <sup>13</sup>C<sub>12</sub> -2,3,7,8 and <sup>13</sup>C<sub>12</sub> -2,3,7,8-TCDF was not recovered.

The florisisil tubes, high flow florisisil cartridges, and PCB swipe samples were analyzed by USAFOEHL Analytical Services. The samples were analyzed using a gas chromatograph equipped with a radio-labeled<sup>63</sup> electron capture detector. The glass fiber filters and high flow florisisil cartridges were extracted with hexane and spiked with 1,1-dichloro-2,2-bis (p-chloro-phenyl) ethene or p,p'-DDE as an internal standard prior to analysis. The swipe samples (3 by 3 inch cotton gauze pads) were also extracted with hexane and analyzed using the same apparatus.

#### PCDD/PCDF

Battelle Laboratory performed the PCDD/PCDF air and swipe analysis using a method developed by (Smith et al, [4]) following the New York State Binghamton Office Building PCB fire. Prior to sampling, the two-stage samplers containing the silica gel absorption cartridges were placed in desiccators and each spiked by Battelle with 2.5 nanograms (ng) of the following isotopically labelled internal standards:

<sup>13</sup>C<sub>12</sub> -2,3,7,8 TetraCDD and <sup>13</sup>C<sub>12</sub> -2,3,7,8-TetraCDF

The samplers containing the absorption cartridges were then returned to Cavalier AFS for sampling. After sampling, the samplers containing the absorption cartridges were wrapped in aluminum foil and placed in desiccators and returned to Battelle for analysis. Battelle placed the absorption cartridges and filters into Soxhlet extractors and spiked them with 5.0 ng each of the following internal standards:

<sup>13</sup>C<sub>12</sub> -1,2,3,7,8-PentaCDD

<sup>13</sup>C<sub>12</sub> -1,2,3,7,8-PentaCDF

<sup>13</sup>C<sub>12</sub> -1,2,3,6,7,8-HexaCDD

<sup>13</sup>C<sub>12</sub> -1,2,3,6,7,8-HexaCDF

<sup>13</sup>C<sub>12</sub> -1,2,3,4,6,7,8-HeptaCDD

<sup>13</sup>C<sub>12</sub> -1,2,3,4,6,7,-HeptaCDF

<sup>13</sup>C<sub>12</sub> -OctaCDD

The samples were extracted for 18 hours with benzene. Each of the benzene extracts, along with its corresponding rinses of the Soxhlet apparatus, were concentrated to approximately 2 ml using Kuderna-Danish and micro-Snyder concentrator tubes. The concentrated extracts were stored in a refrigerator at 10°C until analyte enrichment and analysis using a Carlo Erba Model 4160 high resolution gas chromatograph which interfaced directly into a VG Model 7070-H high resolution mass spectrometer.[5]

Prior to sampling the PCDF/PCDD swipe samples or gauze pads were pre-extracted with benzene for 16 hours in a large Soxhlet apparatus. This was done to remove any interferences that could affect the analyses. After extraction, the pads were placed in separate amber jars and sent to Cavalier AFS for sampling. After sampling, each sample (four gauze pads per sample) was individually transferred to a Soxhlet apparatus and spiked with 5.0 ng of the following internal standards:

<sup>13</sup> C <sub>12</sub> -2,3,7,8-TetraCDD	<sup>13</sup> C <sub>12</sub> -2,3,7,8-TetraCDF
<sup>13</sup> C <sub>12</sub> -1,2,3,7,8-PentaCDD	<sup>13</sup> C <sub>12</sub> -1,2,3,7,8-PentaCDF
<sup>13</sup> C <sub>12</sub> -1,2,3,6,7,8-HexaCDD	<sup>13</sup> C <sub>12</sub> -1,2,3,4,7,8-HexaCDF
<sup>13</sup> C <sub>12</sub> -1,2,3,4,6,7,8-HeptaCDD	<sup>13</sup> C <sub>12</sub> -1,2,3,4,6,7,8-HeptaCDF
<sup>13</sup> C <sub>12</sub> -OctaCDD	

The gauze pads were extracted again, refrigerated, analyte enriched, and analyzed using the same procedure and apparatus as previously described for the PCDD/PCDF air sample cartridges.

### III. EXPOSURE STANDARDS

#### A. General

The National Institute for Occupational Safety and Health (NIOSH) recommends PCBs and TCDDs be considered as potential human carcinogens in the workplace. Limited evidence from animal and human studies suggests PCDFs may also pose a risk to human health. As prudent public health policy, NIOSH recommends occupational exposure to PCBs, PCDFs, and PCDDs resulting from electrical equipment fires or failures be controlled to the lowest feasible limit.[6]

#### B. PCB

The Occupational Safety and Health Administration (OSHA) promulgated its permissible exposure limit (PEL) of 1 mg/m<sup>3</sup> of air for chlorodiphenyl products containing 42% chlorine and 0.5 mg/m<sup>3</sup> for chlorodiphenyl products containing 54% chlorine determined as an 8-hour time-weighted average (TWA). Concentrations were based on the 1968 Threshold Limit Values (TLVs) of the American Conference of Governmental Industrial Hygienists (ACGIH). The TLVs, which have remained unchanged at 1 mg/m<sup>3</sup> (42% and 0.5 mg/m<sup>3</sup> 54% through 1987), are based on the prevention of liver injury in exposed workers. The ACGIH Short Term Exposure Limits (STEL) for chlorodiphenyls are 2 mg/m<sup>3</sup> and 1 mg/m<sup>3</sup> for 42% and 54% chlorine products, respectively. The OSHA PEL and the ACGIH and STEL values include a "Skin" notation which refers to the potential contribution to overall exposure by the cutaneous route, including the mucous membranes and eyes, by either airborne or direct skin contact with PCB.[7]

The National Institute for Occupational Safety and Health (NIOSH) has recommended that the permissible exposure limit for polychlorinated biphenyls be reduced to 1.0 microgram per cubic meter (µg/m<sup>3</sup>) of air averaged over a work shift of up to 10 hours per day, 40 hours per week, and that chlorodiphenyl (42% chlorine) be regulated as an occupational carcinogen.[6] The NIOSH Criteria Document for polychlorinated biphenyls should be consulted for more detailed information.

The Environmental Protection agency (EPA) has established a national PCB surface cleanliness policy. A PCB spill clean-up policy was suggested to EPA by a consensus panel of industry and environmental group officials. The consensus group included the Chemical Manufacturers Association, the Environmental Defense Council, and the Edison Electric Institute.[8]

EPA has adopted this plan. The plan sets solid surface concentrations at an acceptable level of 100  $\mu\text{g}$  per 100  $\text{cm}^2$  for porous surfaces and 10  $\mu\text{g}$  per 100  $\text{cm}^2$  for nonporous surfaces.[3] All contaminated wastes, solvents, and other materials from the PCB clean-up should be properly stored, labeled, and disposed of according to current EPA PCB disposal regulations (40 CFR 761).

#### C. PCDD/PCDF

Currently, no national accepted criteria exists for exposure to dioxins and furans. Different reentry guidelines have been used by health departments in states where PCB fires have occurred. The decontamination guidelines established by the New York State Department of Health (NYSDOH) following the Binghamton fire have received the most attention in the literature and is the criteria USAFOEHL recommends. Criteria used after PCB fires in San Francisco and New Mexico were slightly different.

For the Binghamton fire, the concept of a "2,3,7,8-TCDD equivalent" was used to estimate the toxicological potential of the soot that existed in the building.[9] The 2,3,7,8-TCDD equivalent is an algorithm which includes the measured concentrations of the most highly toxic PCDD and PCDF congeners. The use of the algorithm permits an estimation of PCDF and PCDD concentrations by assigning weighting factors (numbers) to each significant isomer class based on its relative toxicity to 2,3,7,8-TCDD. Table 1 was used to compute the total 2,3,7,8-TCDD equivalent for this survey. Each toxicologically significant PCDF and PCDD isomer concentration was multiplied by its relative class toxicity factor and its chlorine substitution factor. The equivalent concentration was summed to reach a "total sample 2,3,7,8-TCDD equivalent concentration." This procedure was reaccomplished for each sample. Table 2 summarizes the total 2,3,7,8-TCDD equivalent results for each sample.

The NYSDOH assembled an Expert Advisory panel, which consisted of government industrial hygienists and international scientists, to establish reentry guidelines for the Binghamton office building. The panel developed a combined air and surface guideline based on a maximum safe daily intake of 2 picograms per kilogram per day ( $\text{pg/kg/day}$ ) of body weight of 2,3,7,8-TCDD equivalents for a lifetime exposure. This level of intake was derived by applying an uncertainty factor of 500 to a No-Observed-Effect Level (NOEL) of 1  $\text{ng/kg/day}$  in a three generation study of rats. This risk assessment is based on a 50 kg person with a respiratory volume of 10  $\text{m}^3$  per 8-hour day.

$$\frac{1 \times 10^{-9} \text{ g/kg-day (NOEL)}}{500 \text{ uncertainty factor}} = 2 \text{ pg/kg-day}$$

$$2 \text{ pg/kg-day} \times 50 \text{ kg person} = 100 \text{ pg/day}$$

$$100 \text{ pg/day} \times \frac{1 \text{ day}}{10 \text{ m}^3} = 10 \text{ pg/m}^3 \text{ of 2,3,7,8-TCDD equivalent}$$

Although inhalation is the most important route of exposure, exposure via ingestion or skin absorption should be considered as well. Dermal absorption of contaminants would result from skin contact with a contaminated surface. Thus, consideration of the exposure routes lead to a guideline for the maximum acceptable surface contamination. To calculate a surface guideline, assumptions must be made concerning how much skin surface is exposed and how much surface contamination is transferred, absorbed dermally, and ingested each working day. The reentry guideline for surface contamination was calculated to be between 3.3 and 28 ng/m<sup>2</sup> of total 2,3,7,8-TCDD equivalents. Refer to Figure 5. If surface contamination is zero or below the detection limit, then the air limit of 10 pg/m<sup>3</sup> of total 2,3,7,8-TCDD equivalent becomes the reentry guideline. If on the other hand, the airborne value for the TCDD equivalent is nondetectable, then the reentry value will be based entirely on the surface contamination.

#### IV. RESULTS AND DISCUSSION

##### A. Background

The A.F. Meyer team inspected the contaminated area and conducted limited air and swipe sampling inside transmitter cabinets 9 and 10. The inspection revealed the presence of PCB inside the Modulator-Filter cabinets, under the Modulator-Filter units and modulator amplifier cabinets, and underneath the copper ground plates on which the cabinets rest. A PCB air concentration of 0.45 mg/m<sup>3</sup> was detected inside transmitter cabinet 10. Swipe sample results confirmed heavy PCB contamination throughout the interior of both cabinets.[1]

USAFOEHL conducted PCB and PCDD/PCDF sampling inside transmitter cabinets 2, 10, 15 and 16. All were suspected of heavy PCB contamination. Additional PCB air samples were collected in the room. The following samples were collected to quantify the level of PCB contamination and determine if overheat condition produced PCDDs or PCDFs: (1) two PCB oil samples, one from a ruptured capacitor and the other from an overheated A-20 resistor, (2) twenty PCB air and twenty-five swipe samples, and (3) two PCDD/PCDF air and five swipe samples. An additional five air samples for PCB were collected in the room.

##### B. PCB

Data from Table 3 indicated the PCB mixture was oxidized to form PCDDs and PCDFs. Laboratory studies have demonstrated PCDFs are formed from both the oxidative pyrolysis of PCBs and chlorinated benzenes. PCDDs are formed from the oxidation of chlorinated benzenes; however, a capacitor fire at Walnut Peak Generating Station, Columbus, Ohio (March 1984) comprised of approximately 100% PCB produced soot containing PCDDs including 2,3,7,8-tetrachlorinated dibenzodioxin (TCDD). The formation of PCDFs and PCDDs occur at temperatures ranging from 500 to 700°C with an optimal conversion temperature of approximately 600°C. Data in Table 2 show sample 2 (the capacitor) contained 109.0 ng/grams and sample 3 contained 52.0 ng/grams of total 2,3,7,8 TCDD equivalents. The A.F. Meyer team reported maintenance personnel were

exposed to PCB vapors and leaks from electrical components involved with temperatures in the range of 500, to 575°C, however, we could not confirm the capacitors or A-20 resistors were exposed to temperatures in this range.

Table 4 shows PCB air concentrations inside the cabinets were below recommended standards; however, Table 5 shows PCB surface concentrations were above recommended EPA guidelines. As shown in Table 4, the 8-hour TWA concentrations inside the transmitter cabinets and the ambient room concentrations were below the OSHA TWA. Table 5 shows excessive PCB surface contamination was found in transmitter cabinets 2, 10 and 15. The exhaust vents near transmitters 2 and 10 were also heavily contaminated. All of the swipe samples collected in transmitter 10 exceeded the EPA clean-up guideline of 10 µg/100 cm<sup>2</sup> nonporous surfaces. Data from Table 6 show PCB air and surface concentrations averaged the highest (0.78 mg/m<sup>3</sup> and 8579.4 µg/100 cm<sup>2</sup>, respectively) in transmitter cabinet 10. We conclude that transmitter cabinets 2, 10, 15 and the vents are heavily contaminated with PCB.

#### C. PCDD/PCDF

Data from Tables 7 and 8 indicated trace amounts of PCDDs and PCDFs were detected on surfaces and in the air. Both Tables 7 and 8 show detected traces of TetraCDD and TetraCDF through OctaCDD and OctaCDF with OctaCDD and OctaCDF being the most abundant. However, no 2,3,7,8-tetraCDD or 2,3,7,8-tetraCDF was detected in the air samples. Also, sample 6 from transmitter cabinet 15, appears to contain higher concentrations of chlorinated dioxins and furans than any of the other samples. The results show the PCDD and PCDF congener class content increased with increasing chlorination.

The native spike sample was prepared to contain selected PCDD and PCDF isomers at a 500 pg/m<sup>2</sup> level. An average of 87.8 percent recovery of each of the spiked isomers was obtained. The method blank contained trace amounts of the higher chlorinated congener classes, but only for the hexaCDF was this level close to the detectable limits in the actual samples. These trace levels did not interfere with the sample quantifications. Although the internal standard recoveries ranged from 23 to 152 percent, recovery of these internal standards was good with an average recovery of 98 percent, and a relative standard deviation of 27. These recovery values are listed in Table 9.

The first three samples listed in Table 9 are air samples. Since both 2,3,7,8-TetraCDD-<sup>13</sup>C<sub>12</sub> and 2,3,7,8-Tetra-<sup>13</sup>C<sub>12</sub> were spiked onto the silica cartridges prior to the collecting of the sample, the lower 2,3,7,8-TetraCDD-<sup>13</sup>C<sub>12</sub> and 2,3,7,8-TetraCDF-<sup>13</sup>C<sub>12</sub> recoveries may be due to irreversible absorption onto the matrix used to collect these samples, or losses during sample collection.

Because NIOSH and other health professionals recommend occupational exposure to PCDDs, PCDFs, and PCBs be controlled to the lowest feasible limit, USAFOEHL recommends actions be taken to control or reduce exposure to PCDDs, PCDFs and PCB.

## CLEANLINESS CRITERIA

- 2, 3, 7, 8 TCDD EQUIVALENT
- MAXIMUM DAILY INTAKE OF 2 pg/kg-day
- COMBINED SURFACE AND AIR GUIDELINE
- MAXIMUM AIR CONCENTRATION OF 10 pg/m<sup>3</sup>
- SURFACE CONCENTRATION 3 TO 28 ng/m<sup>2</sup>

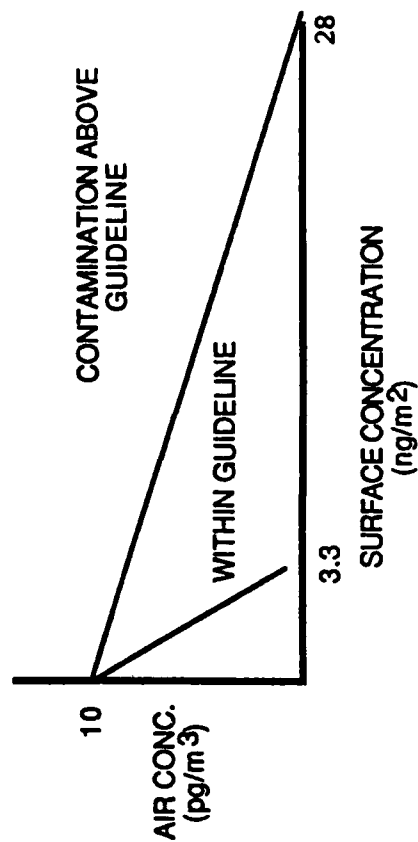


FIGURE -5. PCDD/PCDF CLEANLINESS CRITERIA

## V. RECOMMENDATIONS

A. Recommend maintenance employees be informed about potential health hazards associated with exposure to emissions from PCB containing equipment. All workers should understand exposure can occur through inhalation, ingestion, and skin absorption and that exposure to some of these compounds may result in long-term health effects.

B. Recommend the use of approved full-face air supplied respirators operated in pressure-demand mode during initial response to equipment failures resulting from ruptured capacitors or overheated A-20 resistors. These respirators should be worn during initial response and clean-up procedures and as long as visible amounts of heated PCB exist. If possible, allow time for the electrical components to cool. This will allow the aerosolized PCB to condense on the cooler cabinet surfaces. Include this recommendation in the "PCB Spill, Rupture, and Leaks Response" checklist.

C. Recommend clean-up workers or emergency response personnel wear chemical protective clothing as described below: For clean-up workers, consideration should be given to disposable apparel because of the uncertainty of decontamination of reusable clothing. Workers should wear coveralls made of chemically resistant materials such as Saranax-coated Tyvek or Viton-coated neoprene. Gloves and boots should be made of neoprene, nitrile, butyl rubber, or viton; all have been shown to be resistant to permeation by PCBs. All disposable clothing should be placed in approved containers and disposed of according to EPA disposal procedures (40 CFR 761).

D. Recommend immediate clean-up to include the following: (a) the interior of the transmitter cabinets, (b) ceiling, walls, floors and surfaces in room 301, and (c) the exhaust ventilation ducts from room 301. Triple wash the interior of the cabinets with alkaline detergents or freon solutions. Perform periodic maintenance on the Heating Ventilation Air Conditioning system to include filter bag-house exchange and grill washings.

E. A review of the current literature indicated no national PCB Cleanliness Criteria exists for PCBs, PCDDs, and PCDFs levels after a PCB fire or electrical overhear condition. However, different reentry guidelines have been used by health departments in states where PCB transformer fires have occurred. Pending promulgation of an Air Force or nationally accepted occupational exposure standard for PCDDs or PCDFs, we suggest using the NYSDOH PCB Criteria developed following the Binghamton State Office Building PCB fire. Recommend Table 10 be used as interim guidance to verify PCB, PCDD, and PCDF cleanliness.

## REFERENCES

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9. Kim, K. Nancy, John Hawley. "Re-entry Guidelines Binghamton State Office Building." Bureau of Toxic Substance Assessment Division of Health Risk Control New York State Department of Health, Albany, New York 12237 (August 1984)

APPENDIX  
Result Tables

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Table 1  
CALCULATION OF 2,3,7,8-TCDD EQUIVALENTS

(see notes below)

Isomer or Group	Conc.	Relative Class Toxicity	X	Relative Toxicity of Chlorine Substitution =	2,3,7,8- TCDD Equiv
2,3,7,8-TCDD	<u>C</u>	1	X	1 =	_____
2,3,7,8-TCDF	<u>C</u>	1	X	1 =	_____
Total PentaCDD	C	1	X	0.15 =	_____
Total PentaCDF	<u>C</u>	0.333	X	0.15 =	_____
Total HexaCDD	<u>C</u>	1	X	0.06 =	_____
Total HexaCDF	<u>C</u>	0.333	X	0.05 =	_____
Total HeptaCDD	<u>C</u>	1	X	0.014	= _____
Total HeptaCDF	<u>C</u>	0.333	X	0.014	= _____
Total 2,3,7,8-TCDD equivalents					= _____

Note a: Results may indicate the presence of isomers not listed in Table 1. Only consider the toxicologic significant isomers that are listed in Table 2 for calculation of the total 2,3,7,8-TCDD equivalent.

Note b: To use Table 1, locate the isomer group(s) identified from your sampling results in the Table. Only the isomers found in Table 1 should be considered for this computation. Multiply the isomer group(s) concentration C by the relative class toxicity factor and the chlorine substitution factor. The result is a "2,3,7,8-TCDD equivalent." Do the same for each PCDD and PCDF isomer found in your sample that is shown in Table 1. Then, sum each 2,3,7,8-TCDD equivalent concentration to reach a "total 2,3,7,8-TCDD equivalent concentration".

Table 2

POLYCHLORINATED BIPHENYL (PCB) SAMPLING RESULTS FROM CAVALIER AFS ND  
Total 2,3,7,8-TCDD Equivalent Results

(see notes below)

Sample Type	Sample No.	Location	Total 2,3,7,8-TCDD equiv.
Oil	1	Blank	
	2	trans. 10	*109.0 ng/gram
	3	trans. 2	52.0 ng/gram
Swipe	1	Blank	2.0 pg/m <sup>2</sup>
	2	trans. 2	60.0 pg/m <sup>2</sup>
	3	trans. 2	31.0 pg/m <sup>2</sup>
	4	trans. 10	131.0 pg/m <sup>2</sup>
	5	trans. 10	115.0 pg/m <sup>2</sup>
	6	trans. 15	*357.0 pg/m <sup>2</sup>

\* Samples contain the highest total 2,3,7,8-TCDD equivalents results.

Note a: No total 2,3,7,8-TCDD equivalent concentrations were calculated for the PCDD/PCDF air sample results because the two detected isomers are not considered toxicologically significant for this calculation.

Note b: Swipe sample no. 1 (Blank sample) contained a total 2,3,7,8-TCDD equivalent concentration of 2.0 pg/m<sup>2</sup>. This concentration was substrated from each of the remaining swipe samples of the total 2,3,7,8-TCDD equivalent concentration results. The 2.0 pg/m<sup>2</sup> of total 2,3,7,8-TCDD was considered to be the "background concentration."

Table 3

## POLYCHLORINATED BIPHENYL (PCB) OIL SAMPLING RESULTS FROM CAVALIER AFS ND

Two PCB oil samples (nanograms/gram, ppb)

SAMPLE Type	2378 TCDD	Total TCDD	2378 TCDF	Total TCDF	Penta CDD	Penta CDF	Hex CDD	Hex CDF	Hep CDD	Hep CDF	Octa CDD	Octa CDF
Sample 1 Capacitor C-12	ND <sup>c</sup>	ND <sup>c</sup>	96 <sup>b</sup>	315 <sup>b</sup>	ND <sup>c</sup>	260	ND <sup>c</sup>	13	ND <sup>c</sup>	0.6	ND <sup>c</sup>	ND <sup>c</sup>
Sample 2 A-20 Resistor	ND <sup>c</sup>	0.8	22 <sup>c</sup>	62 <sup>b</sup>	2.9 <sup>b</sup>	350	1.1	490	ND <sup>c</sup>	750	ND <sup>c</sup>	1300 <sup>d</sup>

b Quantitated versus <sup>13</sup>C<sub>12</sub>-PentaCDF due to surrogate spike not recovered

c Nondetected, surrogate spike not recovered

d Quantitated versus <sup>13</sup>C<sub>12</sub>-OctaCDD due to Interference

Table 4

POLYCHLORINATED BIPHENYL (PCB) SAMPLING RESULTS FROM CAVALIER AFS ND  
PCB AIR SAMPLES (florisil tubes)

OSHA/ACGIH 8-Hour TLV = 1.0 mg/m<sup>3</sup>

SAMPLE NO.	TYPE	LOCATION	MILLIGRAMS CUBIC METER	*8-HOUR TWA
1	air	tran. 10	0.7	0.5
2	air	tran. 10	0.8	0.6
3	air	tran. 10	0.6	0.5
4	air	tran. 10	1.0	0.7
5	air	tran. 10	0.8	0.6
6	Blank			
7	air	tran. 2	0.2	0.1
8	air	tran. 2	0.2	0.2
9	air	tran. 2	ND	ND
10	air	tran. 2	0.2	0.2
11	air	tran. 2	0.2	0.2
12	air	tran. 15	ND	ND
13	air	tran. 15	0.0	0.01
14	air	tran. 15	trace	
15	air	tran. 15	ND	ND
16	air	tran. 15	trace	
17	air	tran. 16	0.02	0.01
18	air	tran. 16	0.03	0.02
19	air	tran. 16	0.02	0.01
20	air	tran. 16	trace	
21	air	tran. 16	0.02	0.01

\* Concentration calculation based on 6 hour exposure period  
ND -- Non-detected, PCB concentration less than 0.08 mg/m<sup>3</sup>

PCB AIR SAMPLING (florisil cartridges)

SAMPLE NO.	MICROGRAMS/SAMPLE	VOLUME (m <sup>3</sup> )	MILLIGRAMS/CUBIC METER
1	7	29	0.0002
2	61	33	0.002
3	177	33	0.005
4	119	32	0.004
5	112	32	0.004

Table 5

POLYCHLORINATED BIPHENYL (PCB) SAMPLING RESULTS FROM CAVALIER AFS ND  
PCB Swipe Sample Results ( $\mu\text{g}/100 \text{ cm}^2$ )

100  $\mu\text{g}/100 \text{ cm}^2$  porous recommended to Adopted by EPA 2 Apr 87

10  $\mu\text{g}/100 \text{ cm}^2$  nonporous recommended to Adopted by EPA 2 Apr 87

SAMPLE NO.	TYPE	LOCATION	MICROGRAMS 100 $\text{cm}^2$
1	blank	ND (non-detected)	
2	swipe	vent near tran. 10	12*
3	swipe	vent near tran. 10	11*
4	swipe	vent near tran. 2	6
5	swipe	vent near tran. 2	4
6	swipe	tran. 2	9
7	swipe	tran. 2	6
8	swipe	tran. 2	2
9	swipe	tran. 2	532*
10	swipe	tran. 2	ND
11	swipe	tran. 2	trace
12	swipe	fan tran. 2	103*
13	swipe	tran. 10	136*
14	swipe	tran. 10	754*
15	swipe	tran. 10	222*
16	swipe	tran. 10	57,247*
17	swipe	tran. 10	215*
18	swipe	tran. 10	741*
19	swipe	fan tran. 10	741*
20	swipe	tran. 15	5
21	swipe	tran. 15	19*
22	swipe	tran. 15	13*
23	swipe	tran. 16	6
24	swipe	tran. 16	2
25	swipe	tran. 16	6
26	swipe	tran. 16	2

\*Exceeds 10 micrograms/100  $\text{cm}^2$  concentration

Table 6

POLYCHLORINATED BIPHENYL (PCB) SAMPLING RESULTS FROM CAVALIER AFS ND  
Arithmetic Mean for PCB Air and Swipe Data

Sample Type	Location	Arithmetic Mean
Air	2	0.02 mg/m <sup>3</sup>
	10	*0.78 mg/m <sup>3</sup>
	15	0.02 mg/m <sup>3</sup>
	16	0.025 mg/m <sup>3</sup>
	room	0.003 mg/m <sup>3</sup>
Swipe	2	30.4 µg/100cm <sup>2</sup>
	10	*8579.4 µg/100 cm <sup>2</sup>
	15	12.3 µg/100 cm <sup>2</sup>
	16	4.0 µg/100 cm <sup>2</sup>

\* Transmitter with highest level of air and surface contamination.

Table 7

POLYCHLORINATED BIPHENYL (PCB) SAMPLING RESULTS FROM CAVALIER AFS ND  
PCDF/PCDD Air and Swipe Results

(Limit of Detection)

Sample No.	Units	Location	2,3,7,8-TetraCDD	TetraCDD	PenCDD	HexCDD	HepCDD	OctCDD
Air								
1	pg/m <sup>3</sup>	blank	(<0.98)	(<0.98)	(<1.89)	(<1.06)	(<0.72)	(<3.13)
2	pg/m <sup>3</sup>	trans.10	(<0.74)	(<0.74)	(<1.16)	(<0.64)	(<0.56)	3.0
3	pg/m <sup>3</sup>	trans. 2	(<0.99)	(<0.99)	(<1.58)	(<1.65)	(<0.61)	8.3
Swipe								
1	pg/m <sup>2</sup>	blank	(<7.8)	*(7.8)	(<9.7)	24.0	220.0	2000.0
2	pg/m <sup>2</sup>	trans.2	(<2.2)	(<2.2)	(<7.9)	(<0.8)	210.0	1600.0
3	pg/m <sup>2</sup>	trans.2	(<3.4)	(<3.4)	(<2.5)	(<52.0)	220.0	1700.0
4	pg/m <sup>2</sup>	trans.10	(<4.5)	(<4.5)	(<5.4)	(<1.7)	210.0	1600.0
5	pg/m <sup>2</sup>	trans.10	(<4.5)	(<4.5)	(<3.9)	(<1.5)	230.0	1500.0
6	pg/m <sup>2</sup>	*trans.15	(<4.1)	(<4.1)	(<3.6)	900.0	740.0	2300.0
Native								
Spike	pg/m <sup>2</sup>		460.0	460.0	470.0	450.0	410.0	430.0
Method								
Blank	pg/m <sup>2</sup>		(9.5)	(9.5)	(5.7)	(11.3)	67.0	41.0

\* Transmitter cabinet with the highest dioxins and furans concentrations

Note: When a particular isomer was not found, a limit of detection was calculated using the following formula:

$$\text{LOD per sample, pg/m}^2 = \frac{\text{Hc} \times \text{Qis} \times 2.5}{\text{His} \times \text{Rf} \times \text{Area or Volume}}$$

Where: LOD = Single isomer limits of detection for a congener class in pg  
Hc = Peak height of congener class isomer  
Qis = quantity of internal standard in pg  
His = Peak height of internal standard  
Rf = Response factor  
Area = Area of surface swipe sample, m<sup>2</sup> or Volume m<sup>3</sup>

Table 8

POLYCHLORINATED BIPHENYL (PCB) SAMPLING RESULTS FROM CAVALIER AFS ND  
PCDF Air and Swipe Sample Results

(Limit of Detection)

Sample No.	Units	Location	2,3,7,8-TetraCDF	TetraCDF	PenCDF	HexCDF	HepCDF	OctCDF
Air								
1	pg/m <sup>3</sup>	blank	(<0.85)	(<0.85)	(<0.58)	(<0.48)	(<0.57)	(<1.48)
2	pg/m <sup>3</sup>	trans.10	(<2.85)	2.0	(<0.21)	(<0.42)	(<0.41)	(<0.89)
3	pg/m <sup>3</sup>	trans. 2	(<1.69)	(<1.69)	(<0.50)	(<0.35)	(<0.36)	(<0.92)
Swipe								
1	pg/m <sup>2</sup>	blank	(<30.5)	(<30.5)	(<5.1)	10.0	45.0	78.0
2	pg/m <sup>2</sup>	trans.2	54.0	192.0	74.0	72.6	125.0	157.0
3	pg/m <sup>2</sup>	trans.2	24.0	78.0	34.0	50.0	95.0	123.0
4	pg/m <sup>2</sup>	trans.10	115.0	517.0	190.0	210.0	534.0	2180.0
5	pg/m <sup>2</sup>	trans.10	101.0	444.0	163.0	151.0	392.0	1200.0
6	pg/m <sup>2</sup>	*trans/15	212.0	708.0	967.0	1530.0	1884.0	3020.0
Native								
Spike	pg/m <sup>2</sup>		459.0	459.0	438.0	406.0	451.0	416.0
Method	pg/m <sup>2</sup>		(16.6)	16.6	5.6	22.8	19.4	(38.0)

\*Transmitter cabinet with the highest dioxins and furans concentrations

Note: When a particular isomer was not found, a limit of detection was calculated using the following formula:

$$\text{LOD per sample, pg/m}^2 \text{ or pg/m}^3 = \frac{\text{Hc} \times \text{Qis} \times 2.5}{\text{His} \times \text{Rf} \times \text{Area}}$$

Where: LOD = Single isome limits of detection for a congener class in pg

Hc = Peak height of congener class isomer

Qis = Quantity of internal standard in pg

His = Peak height of internal standard

Rf = Response factor

Area = Area of surface swipe sample, m<sup>2</sup> or Volume m<sup>3</sup>

Table 9

POLYCHLORINATED BIPHENYL (PCB) SAMPLING RESULTS FROM CAVALIER AFS ND  
PCDD/PCDF Recovery Data for Internal Standards, %

Sample No.	2,3,7,8-Tetra CDD	2,3,7,8-Tetra CDF	Penta CDD	Penta CDF	Hexa CDD	Hexa CDF	Hepta CDD	Hepta CDF	Octa CDD
<b>Air</b>									
1 (blank)	42	41	98	96	86	75	81	76	115
2	56	52	99	99	69	73	86	72	107
3	51	53	138	128	120	109	135	118	169
<b>Swipe</b>									
1	118	102	130	100	83	86	84	86	71
2	118	111	89	136	101	104	103	92	98
3	112	98	104	112	120	119	115	106	127
4	92	87	53	83	68	65	77	63	66
5	119	117	23	106	84	79	88	75	97
6	123	118	131	122	109	101	130	99	126
Native Spike	108	94	90	95	89	77	99	85	125
Method Blank	93	86	152	143	145	128	112	143	125

Table 10

RECOMMENDED PCB, PCDD, PCDF CLEANLINESS CRITERIA  
 BASE CLEANLINESS ON COMBINED SURFACE AND AIR CONCENTRATIONS

	<u>Air Concentration</u>	<u>Surface Concentration</u>
PCB	1 mg/m <sup>3</sup> , OSHA PEL	100 µg/100 cm <sup>2</sup> , porous surfaces, EPA 10 µg/100 cm <sup>2</sup> , nonporous surfaces, EPA
PCDD/PCDF	10 pg/m <sup>3</sup> Total 2,3,7,8-TCDD equiv. NYSDOH	3.3 µg/m <sup>2</sup> co 28 ng/m <sup>2</sup> Total 2,3,7,8-TCDD equiv. NYSDOH

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